

# Automation of production processes in fuel and energy complexes

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**Abstract.** Modeling of processes using software is usually carried out in the programming languages C++, Java, JavaScript, Python, Ruby, NET (VisualC#, VisualBasic), etc. Often such applications have a two-tier or three-tier client-server architecture. With a two-tier architecture, the enterprise database management system (DBMS) acts as a server, storing primary technological information in a database (DB).

## 1 Introduction

Automation of the metallurgical industry is already high in modern industries, and it will only grow further. For the branches of electrical engineering, construction, mechanical engineering and others, it makes up the bulk of the costs, both organizational and material [1-6].

## 2 The main part

Charge consumption:

$$\sum_{j=1}^n X_{ij} \leq X_{i\Sigma}, \quad (1)$$

Natural gas consumption:

$$\sum_j V^{III} \leq V^{III}, \quad (2)$$

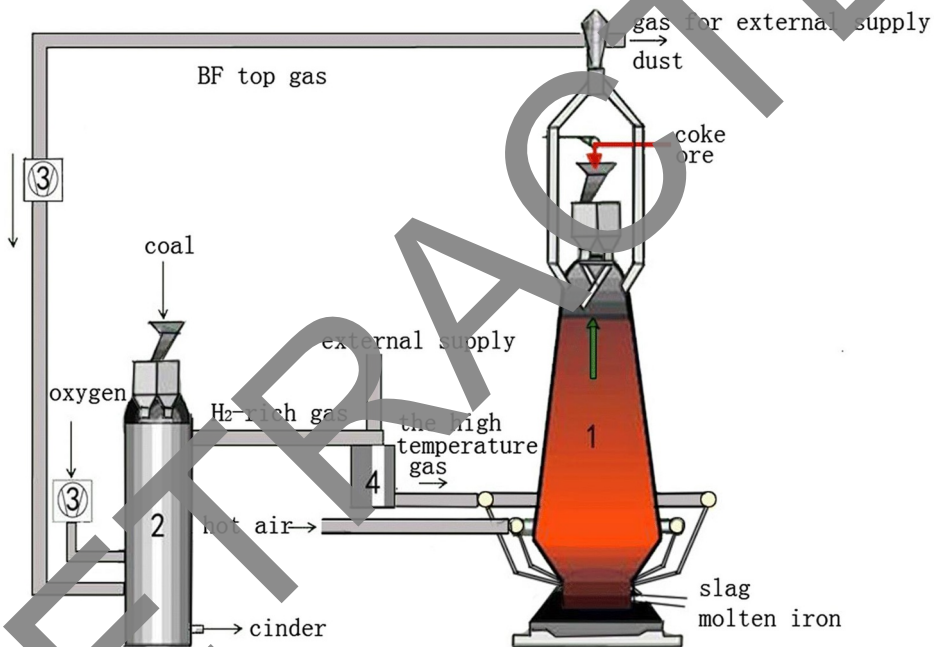
Process oxygen consumption:

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$$\sum_{j=1}^n V^{O_2} \leq V^{O_2}, \quad (3)$$

Cast iron production:

$$\sum_{j=1}^n P_j = P_{\Sigma}. \quad (4)$$



**Fig. 1.** A diagram of the formation of restrictions on the operation of the workshop and the consumption of resources on individual furnaces for the task of optimal distribution of raw materials and fuel and energy resources in a complex of blast furnaces.

It is necessary to control the slagging mode of the device, adjust the gas dynamic parameters and make sure that the furnace does not overheat. To assess whether the device is operating normally, first of all, attention should be paid to the recovery processes when calculating the rate of heat generation, gas pressure, temperature regime and waste generation. Monitoring the system's indicators imposes restrictions on the values of these important indicators.

The interval in which the values of the indicators can be located is chosen, guided by the specifics of the technology of a particular melting in relation to the design and operating parameters of the existing equipment.

Gorenje temperature on tuyeres (theory), °C:

$$T^{min} \leq T_j(V^{III}, V^{O2}) \leq T^{max}, \quad (5)$$

The ratio of the heat capacities of the charge and gas flows in the upper stage of heat exchange, units:

$$m^{min} \leq m_j(V^{III}, V^{O2}, \vec{X}_{y'}) \leq m^{max}, \quad (6)$$

The indicator of the thermal state of the bottom of the furnace, MJ/t:

$$Q^{min} \leq Q_{Hj}(V^{III}, V^{O2}, \vec{X}_{y'}) \leq Q^{max}, \quad (7)$$

Degree of balancing, fractions:

$$CY(V^{III}, V^{O2}, \vec{X}_{y'}) \leq CY^{sp}, \quad (8)$$

The flow rate of the blast from the tuyeres, m/s:

$$w^{min} \leq w_j(V^{III}, V^{O2}) \leq w^{max}, \quad (9)$$

The viscosity of the slag at different temperatures, for example, Pa•c:

$$\eta^{min} \leq \eta_{1400j}(V^{III}, V^{O2}, \vec{X}_{y'}) \leq \eta^{max},$$

Permissible limits of slag bases, for example,  $2=CaO/SiO_2$ , units.:

$$B^{min} \leq B_{2j}(V^{III}, V^{O2}, \vec{X}_{y'}) \leq B^{max}$$

### 3 Materials and methods

Mathematical models are compiled to determine the relevant indicators. And to process the available information, information systems are used to calculate the available technical and economic indicators.

Modeling processes using software is usually carried out in the programming languages C++, Java, JavaScript, Python, Ruby, NET (VisualC#, VisualBasic), etc. Often such applications have a two-level or three-level client-server architecture. With a two-tier architecture, the enterprise database management system (DBMS) acts as a server, storing primary technological information in a database (DB).

The process of data processing in such software, as a rule, includes the need for numerical solutions to problems of mathematical programming, systems of algebraic differential equations, problems of mathematical physics. Such problems cannot be solved using a standard set of mathematical tools for general-purpose programming languages, and third-party mathematical libraries, in particular Extreme Optimization and IMSL Numerical Library, have a high license cost. The Fortran programming language, mathematical application software packages such as MathCAD, MATLAB, Mathematica, and Microsoft Excel are used for scientific and engineering computing. They have a large number of mathematical libraries and routines built into them, but they do not have the means to create a user-friendly interface and do not allow you to develop functional applications. Therefore, when developing information modeling systems, an integration approach with external software is used.

Fortran is one of the first high-level programming languages. Its Fortran95 version compiler was provided, as a rule, with a large number of freely distributed mathematical libraries that were improved and worked efficiently. The disadvantage that complicates the use of the features of the Fortran programming language is the assembly of unmanaged libraries, the behavior of which is unpredictable during execution.

The MathCAD mathematical package uses COM (Component Object Model) technology when integrated with software development tools. Working with COM components requires installing an expensive copy of MathCAD on each end computer of the application, has the problem of software compatibility between library versions and low speed of interaction with COM objects.

The software for the work of engineering and technological personnel must meet the following requirements:

- perform a specific list of functions that meet the established or anticipated needs in accordance with its purpose;
- maintain operability and convert the source data into the desired result under specified conditions for a specified period of time;
- provide users with the necessary conditions and accessibility for use from a given location;
- comply with the operating environment in terms of quality under specified application conditions;
- be adaptable to transfer from one functioning environment to another.

Such requirements ensure prompt access to information while maintaining the functionality and reliability of the software.

All applications can be divided into two large categories: desktop and web. Desktop applications meet the requirements for functionality, reliability and efficiency. However, most often they are developed for a specific hardware and software platform, therefore they do not meet the requirements of accessibility and cross-platform portability. Modern requirements imply prompt access to information, which is impossible to provide with this approach.

Desktop applications with the client-server architecture used are divided into "thick" and "thin" client-dependent functions that run on the client's machine. The architecture of the "thin" client only allows you to increase the speed of cross-platform software development, but does not eliminate the task of developing individual products for each platform.

Modern desktop applications are developed as universal applications that are compiled simultaneously for several platforms. However, they do not fully solve the problem of portability to any platform, be it a smartphone, tablet or laptop.

Another category includes web applications. Web technologies allow you to create applications with different portability. For example, Rich Internet Application (RIA), using technologies from ActiveX, Adobe Flash, Java, Silverlight, do not allow you to create cross-platform and cross-browser. Traditional web applications are accessible from any device that has a browser, and allow you to create adaptive services that provide correct data display on various devices.

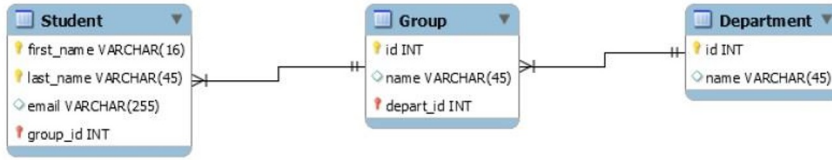
Among the disadvantages of web applications are such properties as their accessibility, the need for a network connection and the inability to launch complex (heavy-weight) projects. The software being developed is client-server, so the problem of connecting to the network is not an actual one. The applications being developed are not heavy, and the problem of accessibility is solved by setting up security rules on the network.

The software infrastructure of the MMK blast furnace shop is based on Microsoft products. SQL Server is used as a DBMS. Existing decision support systems and expert systems are Windows Forms windowed applications or web applications. The target software platform for both types of applications is .NET Framework. The interface and class libraries are written mainly in the object-oriented C# programming language.

Considering the above, for the development of a system for the optimal distribution of raw materials and fuel and energy resources in the domain production, the ASP.NET MVC framework is selected based on .NET Framework. This framework is designed for the development of web applications in the programming language C# using the concept of MVC (Model-View-Controller). MVC is a template for designing software support, according to which the application can be divided into separate components—application data, user interface and control logic. Due to this, the flexibility of software development increases, which ultimately results in a reduction in time for writing program code, testing and debugging. As already noted, an integration approach with external software is used to solve complex mathematical problems in the development of information modeling systems, and the interaction process itself is determined by the selected development tools. Let's consider the features of the integration process of applications developed in the C# programming language with Microsoft Excel and MATLAB.

Integration with Microsoft Excel. The interaction with Microsoft Excel is based on COM Interop technology, which allows COM objects to interact with objects of the software platform .NET Framework. COM Interop technology is supported by connecting the Microsoft Office Interop library. Excel. The library allows you to perform almost any operations that can be performed manually through the user interface. It includes the ability to create and modify cells on workbook sheets, create diagrams, and invoke macros.

Let's consider an algorithm for solving a mathematical problem in the C# programming language with connection to Microsoft Excel. To solve the problem, a pre-prepared spreadsheet file is used, in which the structure of the mathematical model (algorithm for solving a technological problem) and normative reference data for calculation are recorded. This file is embedded in the software being created and opens in hidden mode when the user starts the calculation algorithm. After opening, a predefined range of cells is updated, the calculation process is called, and then its results are read. The call of the calculation process is implemented by a macro.



**Fig. 2.** Mathematical Problem solving algorithm for C# and Microsoft Excel integration.

## 4 Conclusion

In the course of using this approach, a number of disadvantages have been identified:

1. The maximum number of constraints in the "Solution Search" add-in when finding the target function is 100. This limit does not allow you to flexibly solve complex tasks with a large number of restrictions.

2. Low speed of solving the problem. Actions with the spreadsheet file are performed by opening the Microsoft Excel application in the background. Opening takes a long time, and the execution of read and write operations is delayed.

3. The Excel process "freezes" on the user's computer. Even the correct software shutdown of the Microsoft Excel application and the release of the resource side of the application always leads to the real release of resources on the computing station.

4. The need to store the relationship between the application data and the corresponding cells of the spreadsheet file. In other words, the logic of the client application is related to the implementation of the model in an Excel file, so any change to the model often requires reconfiguration of cell ranges and recompilation of the application. The standard Microsoft Excel addressing system by cell address is not very expressive, which complicates the development process. Using the named cell mechanism, when a cell or range is accessed not by its address, but by a symbolic name, solves the problem only partially.

5. The problem of software compatibility of versions. The object library is supplied with the Microsoft Excel application and may not be compatible with the version used in software development. It is necessary to adhere to the rule that the version of the Microsoft Excel program used in the development of the software library must be preinstalled on the user's computer.

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